## A.1: New 20 kW power converters for quadrupole magnets in Indus-2

The existing power converters for quadrupole magnets in Indus-2 were developed about 15 years ago, few of them being still older. Therefore, new, standardized power converters rated for 170 A, 120 V (~20 kW) output have been developed based on switch-mode power converter topology. In this architecture, two sections of two-switch forward converter (TSFC) operate in input-parallel, output-series (IPOS) configuration. So far, ten such power converters have been developed, tested, installed and commissioned by SMPCS, PCD and are operating satisfactorily in round-the-clock operation of Indus accelerators.

The quadrupole magnets of Q1, Q2 and Q3 families in Indus-2 ring are energized with 170 A power converters with compliance voltage of 80 V, 120 V and 100 V, respectively. Output current stability of these power converters is required to be better than ±50 ppm. Existing power converters were based on twelve-pulse controlled rectifier topology followed by transistor series pass regulator whereas some are based on high frequency LCC resonant converters. Some of the components of the existing power converters are reaching their end-of-life. Compatible spares are also not readily available. For better maintainability of these power converters it was thought to develop a standardized converter that would cater to the power converters of the three types. The main features of the new design are: high efficiency, smaller size, less cooling requirement, low audible noise etc. Two sections of TSFC, which are driven by the common duty-cycle command, have inherent load sharing capability. The IPOS configuration also helps in distributing the losses that result in lowering of the stress on the components and switches. Two sections are operated in phase-staggered manner, which helps in reducing ripple at the output. The power converters are designed and developed in modular fashion. The power converter is divided in three modules: power module, breaker module and control rack. Each module is developed and tested separately.

Special endurance such as current cycling test, cyclic on-off tests have been planned and carried out on power converters to simulate different operating modes of the power converter operation in slightly over-stressed conditions for accelerated testing. Power converter has also a feature to prevent false tripping if there is sudden large-signal change in the reference.

Figure A.1.1 depicts a photograph showing assembly details of a cabinet housing two power converters. Figure A.1.2 shows some of the power converter cabinets installed and operational in round-the-clock mode in Indus-2. The measurement data for five converters is consolidated in the form of a histogram as shown in Figure A.1.3. It is clear from the histogram that the stability of the power converter is well within ±50 ppm.

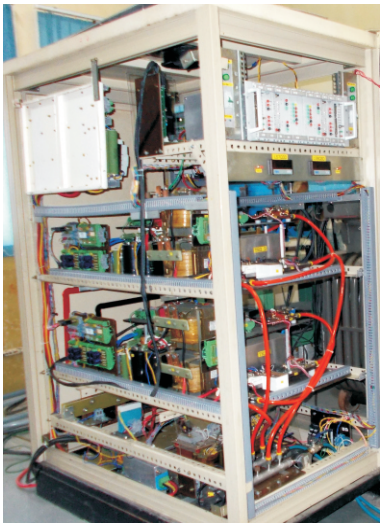

*Fig. A.1.1: Photograph showing assembly details of a cabinet housing two power converters.*

*Fig. A.1.2: Photograph of the new power converters installed and operational in Indus-2.*

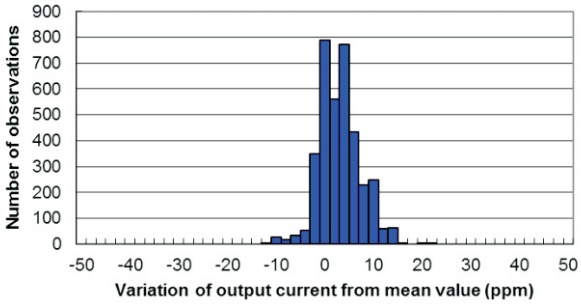


*Fig. A.1.3: Histogram showing stability of five converters.*

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